Clinical Investigation

Electrolyte, Blood Urea Nitrogen and Glucose Level Screening in Medical Admissions

Impact on Patient Management

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Investigators have failed to show the usefulness of screening electrolyte—sodium, potassium, chloride and bicarbonate—blood urea nitrogen and glucose levels. In spite of this, we observed that that practice continues to be widely used at our university medical center. Using a form of consensus analysis, we examined the records of 301 admissions to the medicine service to determine whether laboratory tests were done for diagnostic or screening purposes and whether screening test results led to changes in patient management. Of the 1,764 tests done, 716 (40.6%) were for screening purposes. Only 2 (0.3%) screening test abnormalities led to any therapeutic changes, and many false-positive tests led to unnecessary diagnostic retesting.

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In the early 1960s, automated processes became available for measuring serum chemistries. These processes were perceived as valuable because a wide variety of tests could be done relatively inexpensively using a minimal amount of blood. As a result, many clinicians began to advocate the use of these panels for screening purposes.[1,2] Bryan and coworkers, in fact, thought that the exhaustive search for physical findings and history ought to be paralleled by an equally exhaustive "profile admission chemistry."[3] The use of automated panels for screening became widespread. In the intervening years, however, uniformity of opinion concerning the value of routine screening chemistries has not been achieved.[4-7] The disagreement centers not so much on whether abnormalities will be found but on whether these findings will add new, clinically meaningful data to what is already known about a patient. Thus, in the 1980s physicians continue to order serum electrolyte (sodium, potassium, chloride and bicarbonate), blood urea nitrogen (BUN) and glucose tests with the hope that their patients will benefit from the results.

We undertook this study with three specific objectives: to determine the percentage of patients admitted to the medicine service who were screened for abnormalities in the individual component tests, the diagnostic yield of individual tests and whether the results of screening tests changed patient management.

Methods

The University of California Irvine Medical Center (UCIMC) is a 500-bed tertiary care hospital that serves as the primary teaching facility of the California College of Medicine of the University of California, Irvine. The hospital serves a mixed population that is about 70% indigent and about 30% Spanish speaking. An extensive effort was made to retrieve the charts of all patients admitted to the medicine service during the month of January 1985.

Although we have no institutional or departmental policy regarding the tests to be done on admission to the medicine service, our impression had been that serum electrolyte, BUN and glucose levels were determined on most medical admissions whether or not there were specific indications. These tests can be ordered together as a six-factor multiple-analysis panel. It is less expensive to order the panel than to order individually two or more of the tests on it. We used the nominal group process, a form of consensus analysis, to determine which tests were for screening purposes and which screening tests led to alterations in management. Three faculty members of the Division of General Internal Medicine independently examined the medical records of each patient to determine whether any of the tests in question were done. If a test was done, the record was then evaluated to determine whether a specific indication existed for doing the test or whether it was done purely for screening purposes. We defined "screening" as doing any of these tests on a patient in whom a new abnormality or worsening of a previously known abnormality would not have been suspected from the history or findings of a physical examination. To evaluate this question, specific criteria were developed for each test and the chart was reviewed thoroughly for each of these criteria (see Table 1). For instance, if a patient had a history of polyuria, polyphagia, polydipsia, diuretic or steroid use, chronic pancreatitis or diabetes mellitus, hyperglycemia might have been suspected and the blood glucose determination considered "diagnostic." But if none of these factors were present and a blood glucose level was measured, the examination was considered a "screening" test. Indications for the test were kept

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ABBREVIATIONS USED IN TEXT
BUN = blood urea nitrogen
UCIMC = University of California Irvine Medical Center

narrow and specific. Each of the records was evaluated by using a standard form that contained the indications and criteria. The criteria were agreed on by faculty members of the Division of General Internal Medicine using a consensus approach. Only data available in admission notes were used. Discharge diagnoses were not used to differentiate screening from diagnostic tests since diagnoses may have been generated from results of the screening tests.

After the record was reviewed to determine whether the test was diagnostic or screening, the results of the test were recorded. A judgment was made as to their normality using the standard reference ranges defined by our laboratory. We recognized that for all tests a certain number of "normals" would fall outside the laboratory's specified indices. But we wanted to evaluate the test results as to the manner in which physicians reacted to those results using the defined indices for normal.

After reviewing progress notes and order sheets, another judgment was made as to whether the results led to changes in patient care. Patient care was changed if results appeared to have led to an alteration in either the diagnostic or the therapeutic plan. Each record was reviewed in the same manner to determine if indeed these criteria were fulfilled. In the case of disagreement about the reason a test was done or about a change in patient care, the case was discussed until consensus was reached.

Results

During the month of January 1985, 304 patients were admitted to the medicine service of UCIMC. Of these, the charts of 301 (99%) were available for review. This sample represents about 10% of all medicine service admissions for the year. Consensus was achieved in each case. The results of the review are presented in Table 2. A total of 1,764 individual tests was ordered. All of the tests were done on the six-factor multiple-analyses panel. None were ordered individually. The panel was used for 294 (98%) of the patients. In all, 61 (21%) of the panels were considered to be entirely ordered for screening, and 79 (27%) were either all screening or contained only one diagnostic element. Overall, 716 (40.6%) individual tests were considered to have been done for screening purposes. Of these, 27 (4%) led to a change in test ordering and 2 (0.3%) led to a change in treatment.

The one patient with an abnormal serum sodium level was found to have a value 1 mEq per liter below the lower limit of normal. No action was taken in this case. The low sodium level was not noted as a problem on this admission and had no effect on the patient's course.

Two abnormal serum potassium levels were found. The first was a slightly elevated value noted on a specimen described as hemolyzed. A repeat potassium level without therapy was in the middle of the normal range. The second potassium level was 1 mEq per liter below the accepted range. The patient was a 55-year-old man admitted for chemotherapy for a lymphoma. Treatment consisting of 60 mEq of oral potassium replacement was initiated. Review of the old record showed that although this abnormality had been present in the past, it was not noted in the admission under consideration and was therefore considered a significant screening finding.

Of the seven abnormal chloride levels, all were elevated. Two were repeated and found to be normal. Of the rest, all were within 3 mEq per liter of normal and no chloride level was noted in any record as abnormal or had any meaningful effect on the course of the patient's care. The results did not lead to any change in patient management.

Abnormal bicarbonate levels were found in five of the screened patients. The one elevated bicarbonate level was 1 mEq per liter above normal and was not noted as a problem. Of the four low bicarbonate levels discovered, all were within 2 mEq per liter of normal; two were repeated without therapy and found to be normal, and two were not repeated. In no case was patient care judged to have been altered by an abnormal bicarbonate level.

TABLE 1.—*Criteria for Labeling a Test Diagnostic by History, Signs or Symptoms*

Sodium Level	
Vomiting	Congestive heart failure
Diarrhea	Cirrhosis
Excessive sweating	Hypotension
Excessive fluid intake	Hypertension
Excessive thirst	Dehydration
Polyuria	History of diabetes mellitus or diabetes insipidus
Pulmonary disease	
Central nervous system disease	History of renal disease
	Drugs known to affect sodium level
Potassium Level	
Vomiting	Renal failure
Diarrhea	Muscle weakness
Glucocorticoid excess	Tissue damage
Glucocorticoid deficiency	Hypertension
Digitalis	Diabetes mellitus
Congestive heart failure	Drugs known to affect potassium
Chloride Level	
Vomiting	Suspicion of acidosis
Diarrhea	Suspicion of alkalosis
Mineralocorticoid excess	
Bicarbonate Level	
Vomiting	Drugs causing acidosis
Diarrhea	Acidifying salts
Small bowel drainage	Respiratory disease
Ureterosigmoidostomy	Muscular weakness
Hyperparathyroidism	Congestive heart failure
Suspicion of acidosis	Renal insufficiency
Diuretics	Mineralocorticoid excess
Hyperalimentation	Dehydration
Glucose Level	
Polyuria, polydipsia, polyphagia	Hypoglycemia agents
History of diabetes mellitus	Altered mental state
Chronic pancreatitis	Sweating
Hemochromatosis	Tremor
Glucocorticoids	Anxiety
Pheochromocytoma	Weakness
Cystic fibrosis	Alcohol abuse
Diuretics	
Blood Urea Nitrogen Level	
Urinary tract infection	Sepsis
Altered mental state	Dehydration
Systemic disease associated with renal complications	Congestive heart failure
	Cirrhosis
History of renal disease	Enlarged kidneys
Drugs associated with renal toxicity	Pelvic mass
	Enlarged prostate

TABLE 2.—*Impact of Screening Electrolyte, Blood Urea Nitrogen and Glucose Levels*

Test Done	Total Tests, No.	No. Considered Screening (%)*	No. Abnormal Screening Tests (%)*	Repeat or Additional Tests (%)*	Change in Therapy (%)*
Sodium	294	101 (34.3)	1 (1.0)	0	0
Potassium	294	90 (30.6)	2 (2.2)	2 (2.2)	1 (1.1)
Chloride	294	163 (55.4)	7 (4.3)	0	0
Bicarbonate	294	115 (39.1)	5 (4.3)	2 (1.7)	0
Blood urea nitrogen	294	121 (41.2)	3 (2.5)	0	0
Glucose	294	126 (42.9)	44 (34.9)	23 (18.3)	1 (0.8)
Total	1,764	716 (40.6)	62 (8.7)	27 (3.8)	2 (0.3)

*Numbers in parentheses represent percent of total.

Of the three abnormal BUN levels, one was slightly elevated and two were slightly low. None of these were noted as a problem and none led to any change in management.

The results of the glucose determinations are given in Table 3. Out of 126 screening glucose levels, 44 (35%) were found to be elevated above the normal fasting range. In all, 23 (18%) led to further diagnostic testing and 1 (0.8%) led to a change in therapy. All but one of the specimens for the initial glucose levels were randomly drawn. Of the 23 fasting blood glucose levels done in response to abnormal screening results, only 1 was found to be persistently elevated. The patient was a 60-year-old woman with newly diagnosed gastric carcinoma who was admitted with gastric outlet obstruction. Her admission glucose level in a randomly drawn specimen was 199 mg per dl. A fasting glucose level was never done, but insulin therapy was started concurrently with hyperalimentation that included a solution of 50% dextrose in water. Although it was not clear that the initial screening glucose abnormality contributed to the decision to begin insulin therapy, we included this patient because we could not exclude the possibility.

Of the abnormal glucose values that were not repeated, none were above 200 mg per dl and 18 were below 140 mg per dl, the level below which even a fasting glucose would probably not elicit a therapeutic response.

Discussion

Expensive technologies are often blamed for the rapid inflation of medical care costs. This must in part be the case. Moloney and Rogers have argued, however, that the increased use of a large number of low-cost procedures also adds greatly to this inflation.[9] In this era of limited medical resources, we must ask whether the continued use of a large number of screening tests has been justified by studies that show that these tests contribute in any meaningful way to the management or well-being of patients. Specifically, in the case of determining electrolyte, bicarbonate, BUN and glucose levels, should screening tests be used to search for clinically important abnormalities in patients without specific indications for ordering these tests?

The results of our study are interesting in several respects. First, it is curious that every one of the electrolyte, glucose and BUN levels was ordered on the panel test. This suggests that a significant proportion of the tests may have been ordered without thought for their usefulness. Overall, 40.6% of the tests was purely for screening as defined by our criteria. Most of the screening tests were probably done not for the specific purpose of screening but because they appear on the same panel as a test that was done for another indication. On the other hand, 21% of the panel tests were entirely for screening (none of the six tests on the panel were for diagnostic purposes). Another 6% of the panels contained only one diagnostic examination and, therefore, the panel could not be justified as cost-saving over ordering individual tests. This suggests that, conservatively, about a quarter of the admission laboratory tests evaluated by us were either for the conscious purpose of screening or were ordered reflexively just because a patient was admitted to the hospital. Even though the most recent literature does not support the use of these tests as admission screening tests, this practice apparently continues in our university teaching hospital (a highly cost-conscious institution due to budget constraints). It probably continues in various forms in other institutions as well.

Out of 590 screening electrolyte and BUN test results, only 4 led to diagnostic responses, and only 1 low potassium level proved to have any therapeutic importance. Indeed, it could be argued that even the one case of hypokalemia could have been predicted from a review of the old record.

Of the 44 patients initially found to be hyperglycemic on random admission screening, only 1 (0.8%) was considered to have true hyperglycemia and therefore received therapy. Of the others, 22 (50%) were found to have misleading screening data and the rest for the most part had such minimally elevated glucose levels that it is unlikely that these asymptomatic patients would have proved to have diabetes mellitus. The one patient who was treated was asymptomatic, never had a fasting glucose level and would have required insulin during hyperalimentation in any case.

Our study included important features not present in previous investigations of screening admission testing. We used a form of consensus analysis to determine which tests were ordered for screening purposes and which led to management changes. Most previous studies relied on observations by single observers. While the consensus analysis approach is time-consuming, the conclusions reached are more likely to be generalizable to other settings and less likely to include systematic biases. On the other hand, because of the extensive effort involved in the consensus process, our study included a relatively small sample size. The design was biased against our conclusion, however, since changes in management could possibly have been introduced for reasons other than the results of screening. In addition, contributory elements of the history or physical examination may have been omitted from the recorded data but used in making management decisions.

As Griner and Glaser have pointed out, the electrolyte panel was designed to assist in management, not as a screening test.[7] An actual screening test must be designed with several criteria in mind: It must be relatively sensitive and specific; it must screen for a disease whose prevalence is

high enough to justify screening; it must screen for a disease that is frequently asymptomatic, and it must screen for a disease for which a therapy exists, and for which therapy at an earlier, asymptomatic stage makes an outcome difference over waiting until the disease becomes symptomatic. Even though it is frequently used for screening, the electrolyte panel was not designed with these criteria in mind.

That theoretical criticism aside, we have found little evidence either in our study or in the literature that screening for abnormalities in electrolyte, BUN or glucose levels provides clinically meaningful information. Table 4 summarizes previous studies using our criteria for meaningful data. A number of authors have failed to document the usefulness or to recommend the use of screening laboratory tests.[7,14,18-22]

When investigators examine the usefulness of routine screening laboratory tests, they often evaluate large panels of tests but not individual elements of the panels. Furthermore, they rarely discuss the criteria for medical importance or the usefulness of the findings. In 1965 Bryan and associates reported a study conducted at the Duke University Medical Center (Durham, NC), a veterans hospital and a local community hospital.[3] In that study, the results of a screening panel done on 2,846 admissions were compared with those of a set of values on specimens drawn only on the day of admission at the discretion of the attending physicians or house staff. About one in ten of the patients had an abnormality discovered that was considered important but that would have been missed without the screening. In a subpopulation at the Veterans Administration hospital, all 623 admissions were evaluated for clinically important abnormalities. Although testing uncovered 22 abnormal values (16 glucose, 1 bicarbonate, 1 potassium and 4 BUN), no mention was made of whether the test results affected management in any way. Furthermore, no attempt was described to determine whether or not the abnormalities could have been predicted from clinical data and were therefore not truly screening tests.

Bates and Yellin conducted a study of the usefulness of multiphasic "screening" of outpatients.[11] Their study design did not meet our criteria for screening. They concluded that physician indifference to results, high false-positive rates and a lack of follow-up crippled any screening effort. Indeed, one of the lessons of our study and others is that abnormal results frequently are not noted or acted on by physicians.[14,23,24]

Studies examining the usefulness of electrolyte screening rarely if ever show that screening adds any meaningful information to the management of a patient.[3,10-12,14,15] With the exception of our one mildly hypokalemic patient, screening has virtually never been shown to conclusively lead to a change in management.

Studies examining the usefulness of screening for hyperglycemia have shown somewhat more equivocal results.[3,10,11,14,16,17,25] Because these studies have been conducted in a variety of settings using various analytic methods, it is difficult to compare them directly. In general, they have shown that even under the most careful clinical scrutiny, occasionally a patient will be discovered to have hyperglycemia that would not have been found without screening. Whether this discovery leads to a meaningful change in therapy is not addressed in most of the studies. Where this issue is addressed, the discovery of hyperglycemia does not seem to make much of a difference in ultimate outcome.[12,14,17]

Authors have argued that screening is useful for reasons beyond the pure and simple discovery of new disease—for instance, the usefulness of being able to reassure a "worried-well" patient that he or she is not ill.[24] This does not apply to a patient admitted to hospital with an acute medical illness and therefore could not be applied to the patients in our study.

Although we did not evaluate this element, we wonder whether the practice of screening patients admitted to a medical service might even erode the process of medical evaluation. By depending on screening rather than thinking, physicians might actually lose some of the diagnostic acumen needed to sort out complex problems.

Although no basis exists for such a practice, physicians at our institution continue to order screening admission electrolyte, BUN and glucose levels. Our data do not support this practice. Indeed, our results suggest that screening may possibly do more harm than good because falsely abnormal results may lead to unnecessary patient or physician anxiety and may also generate needless follow-up laboratory tests. Despite some previous studies suggesting that the use of these tests is not productive, our study shows that the practice continues in at least one university hospital. Misconceptions about the value of these tests for screening remain widespread. We urge individual practitioners and institutions to reexamine their policies in this regard. In addition, we urge that medical educators emphasize decision-making processes for the more rational use of electrolyte, BUN and glucose level testing. Decision analysis methods are being developed

TABLE 3.—*Range of Initial Abnormal Glucose Levels and Repeat Values*

Serum Glucose Level, mg/dl	*Initial Fasting Specimens, n = 1*	*Initial Random Specimens, n = 43*	*Repeat Specimens, n = 23*	*Initial Value of Specimens not Repeated, n = 21*
<115	..	..	22	..
115 to 140	1	29	1	18
141 to 200	0	13	0	3
>200	0	1	0	0

TABLE 4.—*Studies Addressing the Usefulness of Screening Electrolyte or Glucose Levels*

Reference	*Screening (by our criteria)**	*Abnormal Results, %*	*Laboratory Change, %*	*Treatment Changes, %*
Electrolytes				
Bryan et al, 1966[3]	NP	0.3	NN	NN
Belliveau et al, 1970[10]	NP	0	NN	NN
Bates and Yellin, 1972[11]	No	NA	NA	NA
Korvin et al, 1975[12]	Yes	1.1	NN	NN
Abdurraham et al, 1982[13]	No	NA	NA	NA
Kaplan et al, 1985[14]	Yes	0.2	0	0
Murata et al, 1985[15]	No	NA	NA	NA
Glucose				
Bryan et al, 1966[3]	NP	2.6	NN	NN
Belliveau et al, 1970[10]	NP	4.0	NN	NN
Bates and Yellin, 1972[11]	No	NA	NA	NA
Korvin et al, 1975[12]	Yes	1.1	NN	NN
Olsen et al, 1976[16]	No	NA	NA	NA
Abdurraham et al, 1985[13]	No	NA	NA	NA
Domoto et al, 1985[17]	No	NA	NA	NA
Kaplan et al, 1985[14]	Yes	0.9	0	0

NA = not applicable, NN = not noted, NP = not possible to determine from methods discussion

*See methods section for a description of our criteria.

for many clinical situations, and training in these should be incorporated into medical education.[26]

Although we cannot determine absolutely whether current test-ordering behavior at our institution represents true screening or simply reflexive test ordering, we know that neither practice provides clinically useful information. "Completeness" should no longer be considered a reason for doing these tests.

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